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ABSTRACT

The effects of conservation activities on children's acquisition of Piaget's conservation concepts were investigated. One hundred and twenty-eight seven-to nine-year-old children in four classrooms were given pre- and post-evaluation measures of conservation ability. The experimental group completed a set of 42 self-directed conservation activities over a five-month period during the 1972-1973 school year. No significant differences in mean conservation scores were found between the experimental and control groups. Several variables were tested for interaction effects on the children's conservation scores. Age interacted with group status to affect conservation scores. Achievement and I.Q. scores were significantly related to the children's conservation scores. Sex, race, and socio-economic status were not significantly related to conservation scores. Further research in conservation acquisition was recommended. (Author)

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EFFECTS OF AN INSTRUCTIONAL SEQUENCE OF ACTIVITIES ON CHILDREN'S ACQUISITION OF PIAGET'S CONSERVATION CONCEPTS

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Piaget's theory of cognitive development has received renewed interest in recent years. Educators have been concerned with the implications of his theory for classroom situations. Several attempts at developing and implementing materials related to mental operations of particular stages have been made. Implications from Piaget's theory may be concerned with the dimensions of action and social interaction in cognitive functioning. Upon examining these dimensions and the behaviors defined by Piaget for particular stages of development, one might begin to derive specific implications for children's elementary school experiences.

This paper presents a description of an investigation in Piaget's concepts of conservation. The study was designed to examine factors relevant to children's acquisition of the conservation concepts. After a brief description of the purpose, procedures, and results of the investigation, several questions based on the results will be discussed.

The purpose of presenting this description and posing questions is to stimulate further questioning. It is hoped that the reader will formulate additional questions related to this research and to possible applications of Piaget's theoretical system in elementary school curricula.

Research pertaining to elementary children's experiences with Piaget's conservation concepts has identified several issues relevant to the present investigation. Several authors have reported evidence of the effectiveness of verbal training pro-

cedures on conservation and related skills (Sigel, Roeper, and Hooper, 1966; Nowak, 1969). Gruen (1965) and Beilin (1965) also reported findings indicating the effectiveness of verbal training methods in producing conservation responses. On the other hand, Wohlwill and Lowe (1962) and Smedslund (1961 c,d) found improvement in children's conservation responses with non-verbal training procedures.

Logical necessity, compensation, and reversibility have been defined by Piaget (1965) as justification responses given by children who are conservers. Several investigators have attempted to classify children's responses to conservation tasks according to these categories. Lovell and Ogilvie (1960) and Smedslund (1961 b) found evidence of these response types among children who conserved. Wallach, Wall, and Anderson (1967) found these conservation responses as a result of conservation training. Sigel (1968) suggested that scoring children's conservation ability according to their justification responses was a reasonable procedure.

Some investigators have raised the question of whether the ability to conserve in one situation transfers to other conservation experiences. Lovell and Ogilvie (1960) and Uzgiris (1964) found little transfer between different tasks measuring the same conservation concept. Other studies have indicated similar non-transfer of children's conservation performance from one conservation concept to another (Wallach, Wall, and Anderson, 1967; Beilin, 1965; Gruen, 1965). Wohlwill (1960) suggested that children's acquisition of a conservation concept might be attributed to more cumulative experiences with the conservation.

PURPOSE

This investigation was concerned with the cognitive processes acquired by children in the Concrete Operational stage of development. At this level, children normally acquire the mental operations necessary to conserve number, substance, length, area, and weight. The purpose of the study was to determine the following:

1. whether or not an instructional sequence of self-directed activities on Piaget's conservation concepts would affect children's acquisition of the conservation concepts.

2. whether or not sex, age, race, school achievement, socio-economic status, and intelligence scores would interact with receiving an instructional sequence of self-directed conservation activities to affect children's acquisition of conservation concepts.

METHOD

The general procedure for this investigation included: the selection of one experimental and two control groups of subjects; the implementation of the experimental materials; and the collection of data for the statistical analyses.

The Sample

Subjects for the study were 128 children from four elementary classrooms in the suburban area of a large midwestern city during the 1972-1973 school year. The experimental group included 37 third-grade children in a team room situation with

two teachers. Control Group 1 consisted of 44 children in two self-contained third-grade classrooms. Control Group 2 included 47 second- and third-grade children in a team room with two teachers. Comparative information about the three groups is presented in Table 1. The three groups were assumed to be initially comparable on all factors under consideration except conservation ability.

Table 1

Comparative Data for the Experimental and Control Groups of Children

Group	Control 1 (Team)	Control 2 (Self-contained)	Experimental (Team)	TOTAL
Number	47	44	37	128
Boys	22	27	19	68
Girls	25	17	18	60
Black	0	17	15	32
White	47	27	22	96
$\bar{X}$ Age	8-2	8-9	8-7	8-5
$\bar{X}$ Achievement Score (T-score)	50.8	42.2	46.9	47.5
$\bar{X}$ I.Q. Score (T-score)	53.7	48.1	48.9	50.4
$\bar{X}$ Socio-economic Score	31	39	38	36

Experimental Treatment

The experimental group and the two control groups completed pre- and post-evaluation measures of conservation ability. The experimental group also completed the experimental sequence

of self-directed conservation activities during the time between the administrations of the two evaluations.

The pre- and post-evaluation measures of conservation ability were administered individually to all children in the study. Volunteer undergraduate teacher-education students from the University of Missouri - St. Louis were trained to administer the measures to the children. Both measures included ten tasks: two tasks for each of the conservation concepts of number, substance, length, area, and weight. The same tasks were used for both measures. Descriptions of several of the tasks are included in the Appendix.

The experimental materials included a set of forty-two self-directed activities. Ten were related to the conservation concept of number, eight to substance, eight to length, eight to area, and eight to weight. Several examples of the experimental activities are described in the Appendix. The activities were designed to provide children with experiences with concrete materials related to the conservation concepts. The entire set of activities was implemented with the experimental group of children over a five-month period.

The materials were made available to the children through the use of an interest-center technique. The conservation activities were displayed and stored in a small area designated for this purpose. The directions were transmitted via a cassette tape recorder with headphones. The materials and tapes were color-coded for identification by the children.

In each activity, the child was instructed to manipulate the materials in such a way that their physical appearance was altered and, in most cases, returned to its original state. The child was free to experiment in any other way with the materials once he had completed the given instructions. There was no evaluation of the child during or after completion of the activities. The questions included in the directions were intended to be stimuli for further manipulation. They were not intended to elicit verbal affirmations of conservation.

Social interaction was encouraged throughout the implementation of the experimental activities. The children were asked to discuss the activities with the teachers or with other children. The timing and completion of the conservation activities was based on the children's selection. It was hoped that this provision for self-direction, as well as the opportunity to explore the properties of concrete materials, would allow the children experience in exercising their internal, logical reasoning.

Data Collected

Data for the statistical analyses included scores on the pre- and post-evaluation measures. Scores were obtained by assigning point values to the children's conservation responses. Responses were elicited by the evaluators' questioning procedures on the conservation tasks. A total of three points was possible for each task: one for logical necessity, one for compensation, and one for reversibility. Thirty points were possible for the entire set of ten tasks.

Data for the other variables were obtained from the children's permanent records. These included age, sex, race, achievement socres, I.Q. scores, and socio-economic status. Achievement scores included reading scores from the Gates-McGinitie Reading Test and the Metropolitan Achievement Test. General intelligence ratings were obtained from the Cognitive Abilities Test, Lorge-Thorndike Intelligence Test, Slosson Intelligence Test, and Weschler Intelligence Scale for Children. Achievement and I.Q. scores were converted to T-scores for purposes of comparison. Socio-economic status was determined by using the Occupational Scale of Hollingshead's (1957) Two Factor Index of Social Position.

RESULTS

As previously stated, this investigation was implemented to determine:

1. the effects of an instructional sequence of self-directed activities related to Piaget's conservation concepts on children's ability to conserve.

2. the interaction effects of sex, age, race, school achievement, socio-economic status, and intelligence scores with the instructional sequence of self-directed activities on children's ability to conserve.

Main Effect

A one-way analysis of variance design on the scores from the pre-evaluation measure of conservation ability yielded significant results ($F = 7.02$, with 2 and 125 degrees of freedom; $p < .01$). Since the initial differences among the mean conservation scores of

the three groups were significant, a one-way analysis of covariance design was used to test for differences in mean achievement between the experimental and control groups on the post-evaluation measure. The post-test mean scores of the three groups, after adjusting for initial differences in pre-test scores, are presented in Table 2. The summary statistics for the analysis of covariance are presented in Table 3.

The obtained value of F, 2.3911, with 2 and 113 degrees of freedom, was not statistically significant. There were no significant differences among the mean scores obtained by the three groups on the post-evaluation measure of conservation ability after adjusting for pre-test differences.

Interaction Effects

A two-way factorial mixed model covariance design with average n adjustments for unequal cell sizes was used to test the interaction effects of the other variables identified in the investigation. These variables were:

Sex - Male, Female

Age - eight years, nine years

Race - Negro, Caucasian

Achievement - high, average, low

Socio-economic Status - average, low

I.Q. Score - high, low.

The adjusted means for the interaction analyses are presented in Table 4. The results of the two-way factorial analyses of covariance on the six variables are presented in Table 5.

Table 2

Means by Group for the One-way Analysis of Covariance
for Post-test Conservation Scores

Group	Control 1		Control 2		Experimental		Total	
	Mean	Number	Mean	Number	Mean	Number	Mean	Number
Pre-test	11.24	41	8.28	40	14.25	36	11.15	117
Post-test	15.34	41	15.18	40	14.72	36	15.09	117
Adj. Post-	15.30	41	16.58	40	13.21	36	15.09	117

Table 3

Summary Table for the Post-test Scores
One-way Analysis of Covariance
Covarying Pre-test Scores

Source of Variance	S.S.	d.f.	M.S.	F
Between	189.10	2	94.55	2.3911
Within	4468.27	113	39.54	
Total	4657.37	115		

Table 4

Adjusted Means for the Two-way Factorial Analyses of Covariance on Post-test Scores

Interaction	Group	Control 1 Mean	Control 1 Number	Control 2 Mean	Control 2 Number	Experimental Mean	Experimental Number	Total Mean	Total Number
Group by Sex	Male	13.43	19.500	15.68	19.500	13.10	19.500	14.07	58.500
	Female	16.44	19.500	17.68	19.500	13.77	19.500	15.96	58.500
	TOTAL	14.94	39.000	16.68	39.000	13.44	39.000	15.02	117.000
Group by Age	8 years	15.15	17.167	11.35	17.167	14.94	17.167	13.82	51.501
	9 years	16.76	17.167	16.79	17.167	11.87	17.167	15.14	51.501
	TOTAL	15.96	34.334	14.07	34.334	13.42	34.334	14.48	103.000
Group by Race†	Black			14.50	19.000	11.47	19.000	12.99	38.000
	White			16.77	19.000	14.19	19.000	15.48	38.000
	TOTAL			15.63	38.000	12.83	38.000	14.23	76.000
Group by Achievement	High	14.54	12.000	19.39	12.000	16.31	12.000	16.74	36.000
	Average	16.39	12.000	17.19	12.000	13.11	12.000	15.57	36.000
	Low	12.50	12.000	14.54	12.000	12.11	12.000	13.05	36.000
	TOTAL	14.48	36.000	17.04	36.000	13.84	36.000	15.12	108.000
Group by Socio-economic	Average	15.86	18.830	15.05	18.830	14.70	18.830	15.20	56.490
	Low	12.56	18.830	15.80	18.830	13.51	18.830	13.96	56.490
	TOTAL	14.21	37.660	15.42	37.660	14.10	37.660	14.58	113.000
Group by I.Q.	High	15.30	19.000	18.15	19.000	16.47	19.000	16.64	57.000
	Low	14.17	19.000	14.50	19.000	10.57	19.000	13.08	57.000
	TOTAL	14.73	38.000	16.32	38.000	13.53	38.000	14.86	114.000

†The group by race analysis was not done on Control Group 1.

Table 5

Summary Table for the Two-way Analyses of Covariance on Post-test Conservation Scores

Interaction	Source of Variance	S.S.	d.f.	M.S.	F
Group by Sex	Between				
	Groups	205.73	2	108.86	2.4024
	Sex	104.85	1	104.85	2.4489
	Groups by Sex	26.86	2	13.43	n.s.
	Within	4709.79	110	42.82	
Group by Age	Between				
	Groups	118.58	2	59.29	1.1915
	Age	44.41	1	44.41	n.s.
	Groups by Age	314.33	2	157.17	3.1584*
	Within	4776.98	96	49.76	
Group by Race	Between				
	Groups	149.92	1	149.92	3.3159
	Race	118.14	1	118.14	2.6129
	Groups by Race	0.98	1	0.98	n.s.
	Within	3210.10	71	45.21	
Group by Achievement	Between				
	Groups	206.13	2	103.06	2.4858
	Achievement	256.44	2	128.22	3.0926*
	Groups by Achievement	91.57	4	28.89	n.s.
	Within	4063.04	98	41.46	
Group by Socio-economic	Between				
	Groups	44.83	2	22.41	n.s.
	Socio-economic	47.91	1	47.91	n.s.
	Groups by Socio-econ.	72.88	2	36.44	n.s.
	Within	5103.81	106	48.15	
Group by I.Q.	Between				
	Groups	149.48	2	74.74	1.9982
	I.Q.	362.31	1	362.31	9.6862**
	Groups by I.Q.	108.77	2	54.39	1.4539
	Within	4002.29	107	37.40	

*F is significant beyond the .05 level.
**F is significant beyond the .01 level.

Analysis of the data indicated that sex, race, and socio-economic status were not found to be significant variables related to children's conservation scores. No interaction between any of these variables and the treatment was found.

Age. The results for age indicated a significant group by age interaction ($F = 3.1584$, with 2 and 96 degrees of freedom; $p < .05$). It seems that age interacted with group status to affect children's conservation scores. An eta coefficient of .2484 was obtained on the significant F value for groups by age. Therefore, about 6 per cent of the variance in children's conservation scores may be accounted for by both age and group status.

In order to determine if any pairs of cell means for post-test scores were significant, t-tests were calculated between the means for eight- and nine-year-olds in each of the three groups. The obtained t-score of 2.2591, with 32 degrees of freedom, for Control Group 2 was significant beyond the .05 level. The t-scores for the other two groups were not significant. Age made a significant difference in the conservation scores of children in Control Group 2, but not in the other two groups.

Achievement. In the analysis of the achievement by group interaction, the obtained value of F, 2.0926, with 2 and 98 degrees of freedom, was significant beyond the .05 level. There were significant differences in the children's conservation performance related to achievement level. An eta coefficient of .3087 was obtained on the significant F value. About 9 per cent of the variance in conservation scores can be accounted for by achievement level. The group with the highest general achievement level

obtained the highest mean conservation score. Similarly, the second highest group on conservation was the second highest general achievement group, and the lowest group on conservation was the lowest general achievement group. Status on achievement level corresponded with conservation scores.

I.Q. Score. Analysis of the I.Q. score by group data indicated a significant interaction. The obtained F value, 9.6862, with 1 and 107 degrees of freedom, was significant beyond the .01 level. There were significant differences in children's conservation scores corresponding to their I.Q. levels. An eta coefficient of .2880 on the significant F value indicated that about 8 per cent of the variance in conservation scores can be accounted for by I.Q. level. The high I.Q. group tended to score significantly better on the post-test than the low I.Q. group.

CONCLUSIONS

Several conclusions based on analysis of the results of this investigation follow:

1. The sequence of self-directed conservation activities did not significantly affect the children's acquisition of conservation concepts.

2. There was a significant interaction between age and group status relating to conservation scores. Nine-year-old children in Control Group 2 performed significantly better than did eight-year-old children in that group. Age in the other two groups was not a significant factor affecting conservation scores.

3. School achievement scores were significantly related to the children's conservation performance in all three groups.

Children with higher achievement scores acquired higher conservation scores than the other children. The level of school achievement corresponded with conservation scores.

4. I.Q. scores were significantly related to conservation scores in all three groups. Children with high I.Q. scores performed significantly better on the post-test than did children with low I.Q. scores.

5. Sex, race, and socio-economic status did not significantly affect children's conservation scores. No significant interaction was found between any of these variables and the treatment to affect conservation scores.

A number of possible questions may be derived relating to these conclusions and to the implementation of this investigation.

Might the experimental materials be more appropriate if introduced at an earlier age, when children are just beginning to develop conservation behaviors, or at a later age, when children are consolidating previous conservation experiences? Were the conservation activities implemented over a time period which was too short for observable developmental change? Are the effects of the conservation activities more long-term and hence measurable at some time beyond the period of the investigation?

Was the experimental treatment thorough enough to affect the children's conservation ability? Would a more thorough and integrated experience with conservation activities influence generalizable conservation ability?

I.Q. score and achievement level were both found to significantly relate to conservation scores. These findings lend

validity to the measure of conservation ability used in this investigation. Can a measure of conservation ability be used to identify ability levels of children, as I.Q. and achievement scores have been used?

The children in this investigation were initially comparable on socio-economic status. Essentially, most of the children were rated as low average or low socio-economic level. No differences were found between these groups on the measure of conservation ability. Would differences be found among children with more marked cultural differences?

Did the type of classroom situation influence the performance of the three groups? Did the children's performance and verbalizations on the pre-test reflect their classroom experiences, especially in the experimental group? Were teacher influences also related to children's performance on the pre-test?

Could other effects have occurred aside from competence in specific conservation operations? Were other areas of learning affected, such as the ability to handle learning tasks not directly related to the conservation concepts? Was motor ability influenced, especially among younger children? Could the children's exploration of the conservation materials contribute to their ability to handle other problem-solving situations?

Are other variables more highly related to conservation ability than the variables identified in this study? Could such variables as physical development, motor ability, children's self-perception, and type of classroom organization be related to performance in conservation?

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APPENDIX

Examples of the Pre- and Post-test Tasks

Examples of the Experimental Conservation Activities

NUMBER 1 Marbles

Show the child the two containers with the marbles in the tall, thin container.

ASK: What would happen if you pour the marbles into the short, fat glass? Would there be more marbles, fewer marbles, or the same number of marbles?

Have the child pour the marbles into the short, fat glass.

ASK: Are there more marbles, fewer marbles, or the same number of marbles now? How do you know?

ASK: Questions necessary to determine whether the child has logical necessity, compensation, reversibility.

SCORE: 1 point each for logical necessity, compensation, reversibility.
TOTAL POINTS POSSIBLE: 3

NUMBER 2 Buttons

Lay out one row of buttons. Have the child lay out another row with the same number of buttons beneath the first row. The child should agree that both rows have the same number of buttons.

Spread out one row.

ASK: Which has more buttons, my row or your row? Or do they both have the same number of buttons? How do you know?

Make one row of buttons into a circle.

ASK: Which has more buttons, the circle or the row? Or do they both have the same number of buttons? How do you know?

ASK: Questions necessary to determine whether the child has logical necessity, compensation, reversibility.

SCORE: 1 point each for logical necessity, compensation, reversibility.
TOTAL POINTS POSSIBLE: 3

SUBSTANCE 1 Clay

Show the child the two balls of clay. Have him agree that the two balls contain the same amount of clay. If necessary, let him change them until he agrees that they have the same amount of clay.

ASK: What would happen if you roll one of the balls into a long snake? Would the snake have more clay, less clay, or the same amount of clay as the ball?

Have the child roll out one ball into a snake.

ASK: Does the snake have more clay, less clay, or the same amount of clay as the ball? How do you know?

ASK: Questions necessary to determine whether the child has logical necessity, compensation, reversibility.

SCORE: 1 point each for logical necessity, compensation, reversibility.
TOTAL POINTS POSSIBLE: 3

SUBSTANCE 2 Water Level

Show the child the two containers with the water in the short, fat glass.

ASK: What would happen if you pour the water into this tall, thin glass? Would there be more water, less water, or the same amount of water?

Have the child pour the water into the tall, thin glass.

ASK: Is there more water, less water, or the same amount of water now? How do you know?

Then show the child the three small glasses.

ASK: If you would pour the water into these three small glasses, would there be more water, less water, or the same amount of water?

Have the child pour all the water into the three small glasses.

ASK: Is there more water, less water, or the same amount of water now? How do you know?

ASK: Questions necessary to determine whether the child has logical necessity, compensation, reversibility.

SCORE: 1 point each for logical necessity, compensation, reversibility.
TOTAL POINTS POSSIBLE: 3

LENGTH 1, Wires

MATERIALS: 2 pieces of doorbell wire 12 inches long
2 pattern cards showing an "S" shape and a "C" shape

DIRECTIONS: The children laid both wires side by side to see that they were the same length. They then used one of the wires to make designs.

They made two designs by following the pattern cards: "S" and "C".

The children then made 5 designs of their own from the wire. Suggestions included: a snake, a circle, a spring.

LENGTH 2, Pegs

MATERIALS: one board with 4 plastic pegs arranged in a cross design
one piece of yarn connected to the board

DIRECTIONS: The children used the yarn and the pegs to make designs. They put the yarn around the pegs to make: a diamond, a triangle.

The children then made 3 of their own designs. Suggestions: a flower, a star.

LENGTH 3, Car Tracks

MATERIALS: a board with 3 car tracks: straight, zig-zagged, and squared
3 cars: one for each track
flashlight bulbs connected to 2 of the cars

DIRECTIONS: The children used the board with the 3 car tracks. The car on the straight track was the lead and had no light bulb. The other 2 cars had flashlight bulbs connected to a transformer. The board was wired so that when the cars were in the same position as the lead car, the bulbs would light.

The children moved the lead car along its track. They moved the other 2 cars the same distance. When the cars went the same distance, the bulbs would light.

WEIGHT 4, Cups

MATERIALS: equal arm balance
one small paper cup
small tiles for standard units

DIRECTIONS: The children first weighed the paper cup. They then smashed the cup so that it was flat. They weighed it again to see how many tiles were needed to balance the cup after it was flat.

WEIGHT 5, Ice Cubes

MATERIALS: equal arm balance
small tiles for standard units
1 ice cube in closed 30 cc container

DIRECTIONS: The children were instructed to weigh the ice cube and write down how many tiles it took to balance it.

They then kept the ice cube until it melted. They weighed the melted ice cube and compared this weight with their first number.

WEIGHT 6, Plastic Bag

MATERIALS: equal arm balance
small plastic sandwich bag
paper clips for standard units

DIRECTIONS: The children were asked to place the plastic bag in the balance and find out how many paper clips it needed to balance.

They then crumpled up the bag and weighed it again. They compared this weight with their first finding.